STRATFORD/AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT

STRATFORD-AVON RIVER ENVIRONMENTAL
MANAGEMENT PROJECT

GROWTH OF AQUATIC PLANTS IN THE AVON RIVER

Technical Report No. S-6

S. Thornley
Southwestern Regional Office
Ontario Ministry of the Environment

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PREFACE

This report is one of a series of technical reports resulting from work undertaken as part of the Stratford-Avon River Environmental Management Project (S.A.R.E.M.P.).

This two-year Project was initiated in April 1980, at the request of the City of Stratford. The S.A.R.E.M.P. is funded entirely by the Ontario Ministry of the Environment. The purpose of the project is to provide a comprehensive water quality management strategy for the Avon River basin. In order to accomplish this considerable investigation, monitoring and analysis has taken place. The outcome of these investigations and field demonstrations will be a documented strategy outlining the program and implementation mechanisms most effective in resolving the water quality problems now facing residents of the basin. The project includes assessment of urban, rural and in-stream management mechanisms for improving water quality.

This report results directly from the aforementioned investigations. It is meant to be technical in nature and not a statement of policy or program direction. Observations and conclusions are those of the author and do not necessarily reflect the attitudes or philosophy of all agencies and individuals affiliated with the Project. In certain cases the results presented are interim in nature and should not be taken as definitive until such time as additional support data are collected.

Reference to equipment, brand names or supplies in this publication is not to be interpreted as an endorsement of that particular product or supplier.

Enquiries with respect to this report should be directed to the author or

Ministry of the Environment,
Southwestern Region,
985 Adelaide Street South,
London, Ontario.
N6E 1V3
(519) 681-3600

ABSTRACT

This report documents heavy growths of aquatic plants in the Avon River in 1980 and 1981, which were heavier than in most other Southern Ontario rivers. The heavy growths were apparently being sustained by high levels of phosphorus in conjunction with other favourable growing conditions. Phosphorus in samples of plant tissues was well in excess of the level that would limit growth. The total river biomass, which averaged 49,550 kg during the months of May to August, was demonstrated to be the major cause of low night-time concentrations of dissolved oxygen in river water. During darkness, the oxygen demand from aquatic plants was approximately thirty-six times the oxygen demand from the Stratford WPCP effluent.

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INTRODUCTION

A 1979 report by the Ontario Ministry of the Environment presented the findings of an investigation into the impact of various wastes on the water quality of the Avon River. One of the impacts identified was the presence of excessive quantities of certain aquatic plants growing in response to nutrient wastes in the river. One nutrient in particular, phosphorus, was identified as the controlling nutrient. There is a relationship between the concentrations of phosphorus in water, the concentration of phosphorus in plant tissue and the biomass of the plants. By measuring biomass and by measuring the concentration of nutrients (particularly phosphorus) within that biomass it should be possible to estimate the needed reduction of phosphorus in water to reduce plant growth in the river to a more acceptable level. More specifically, phosphorus should be reduced such that the resulting plant biomass will not detrimentally interfere with the oxygen content of the Avon River.

This particular paper outlines the collection of plants, the weighing of plants collected and the concentration of phosphorus measured in the plant tissue. In conjunction with the findings of other reports, especially those presenting the concentrations and sources of phosphorus in the water, insight will hopefully be gained into any need and means to control the access of phosphorus into the Avon River.

METHODS

Through the coordination and financial support of SAREMP, two students were hired during each of the years

1980 and 1981, to devote part of their time to the collection of plant biomass from the Avon River. Eight stations were chosen for data collection (Figure 1). One station was located upstream from the Stratford Water Pollution Control Plant (WPCP) discharge with the other seven located downstream. Based on 1977 work and recent survey reconnaisance it was known that unsuitable substrate upstream from Station 6 limited plant growth to much lower densities.

1980 SAMPLING

Stations were sampled approximately bi-weekly from May 28 to August 21 (7 samples). Three quadrats were collected from each station during each sampling. Each quadrat was collected by placing a Surber sampler in the river and removing all plant growth within the Surber frame (1 foot by 1 foot). Detached plant material was collected in the Surber bag. Because of the variability in growth, three random quadrats did not provide adequate representation. Consequently, quadrat location was not random and samples were collected such that the area harvested was representative of the general growth conditions at a station. The collection of three quadrats was the maximum effort the program could support. Excess moisture was wrung from samples which dried further while stones and detritus were separated from plant material. After excess moisture had been removed from a sample, a sample wet weight was determined and recorded. Samples were then oven-dried and a dry weight recorded. Eventually, an ash weight was obtained to allow for the calculation of loss-on-ignition, indicative of the proportion of organic material in the sample.

Also in 1980 total nitrogen and total phosphorus concentrations in plant tissue were measured for each sample (i.e. each quadrat). Field sheets were completed to record

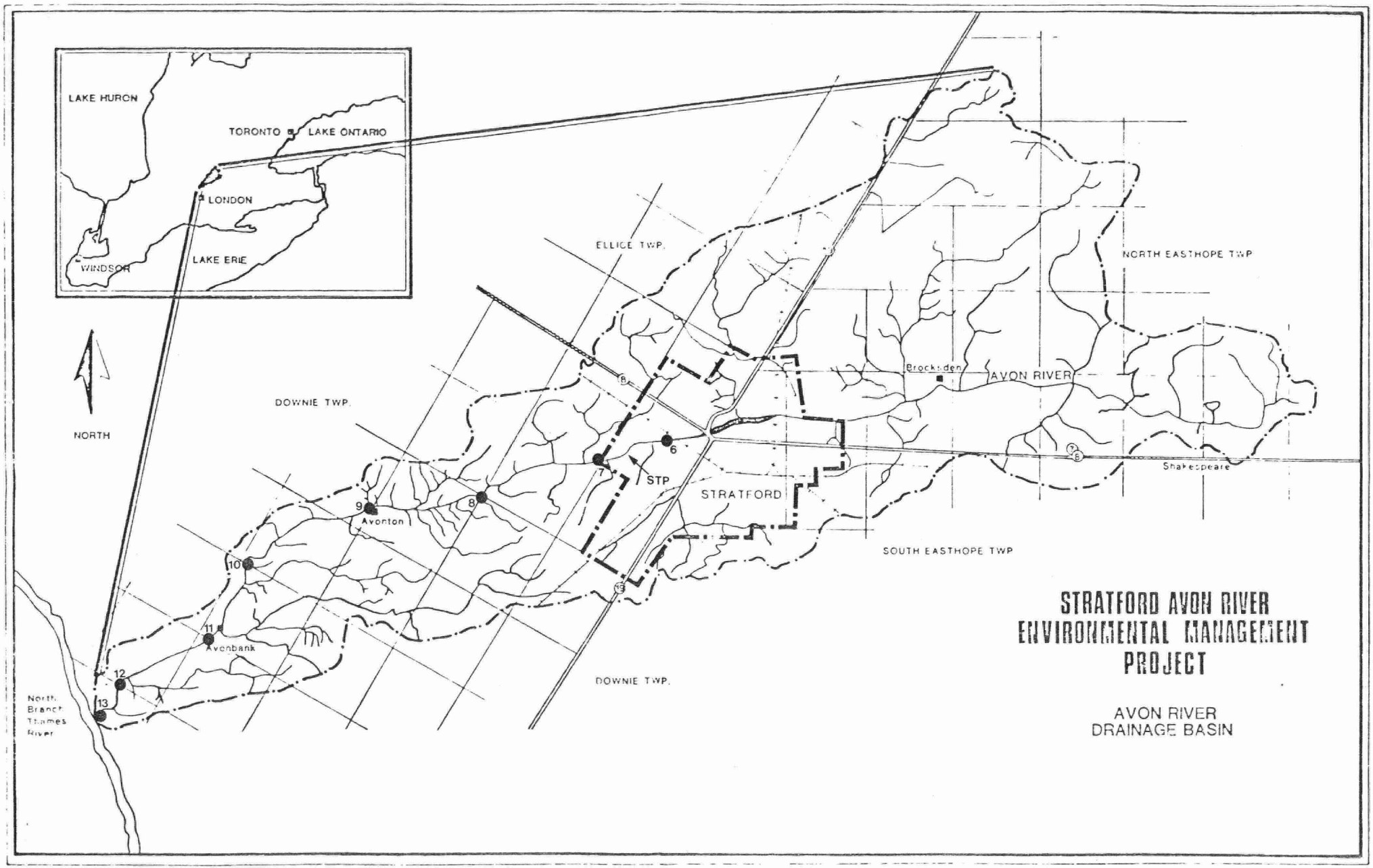

Figure 1. Biomass monitoring stations, Avon River, 1980-1981.

the type and distribution of plant growth harvested along with miscellaneous field data and observations. All analyses were performed at Ontario Ministry of the Environment laboratories (O.M.E. 1981).

1981 SAMPLING

The 1981 sampling format was very similar to that of 1980. The same eight stations were sampled bi-weekly from late May to late August (seven samples). No nutrient concentrations were measured from the plant tissue samples since sufficient information was collected in 1980. In addition to the quadrat sampling, the percentage area of the river (in a reach of approximately 30 meters long) with growth characteristics similar to growth in the quadrats was estimated in 1981 on each visit to a station. The plant biomass was then weighted based on the percentage of the river that had similar plant density and composition to the quadrat samples, which allowed for the calculation of a total weighted biomass. This was done to allow for a reasonably accurate extrapolation of data over the larger area as shown in the following example. This river width in the example is 6 meters and the reach length as already mentioned is 30 meters.

e.g. Quadrat sample A - 63.5 gm/m² (dry weight), representative of 50 percent of river (30 meters long X 6 meters wide).

Quadrat sample B - 20 gm/m², representative of 35 percent of river (30 x 6)

Quadrat sample C - 13 gm/m², representative of 15 percent of river (30 x 6).

Arithmetic Average (gm/m^2)

$$\frac{63.5 + 20 + 13}{3} = 32\ gm/m^2$$

Weighted Average (gm/m^2)
(for 180 m^2 area)

$$(63.5)(.5 \times 180) + (20)(.35 \times 180) + (13)(.15 \times 180) / 180$$
$$= \frac{7529\ gm}{180\ m^2} = 41 gm/m^2$$

RESULTS

Tables 1 and 2 present biomass results from 1980 and 1981 respectively. Table 1 also includes phosphorus concentrations measured in plant tissue samples. Looking at the average station biomass collected during any sampling period (seven per year), it can be seen (from Figure 2 and Figure 3) that 1981 produced more growth than 1980. The averages of all sample weights for 1980 and 1981 were 73.4 and 148.6 gm/m^2 respectively. During 1980 biomass was more variable along the river and was less for three consecutive reaches downstream from the WPCP than the average upstream (Station 6 to Station 7). Biomass for the reaches along with physical data for the stream can be found in Tables 3 and 4.

Ninety-five quadrat samples collected during 1980 were sub-sampled for the measurement of nitrogen and phosphorus concentrations in plant tissue. Wong and Clark (1976) found a phosphorus concentration of 1.6 mg/g dry weight to be critical. That is, the minimum concentration of in-tissue phosphorus necessary to sustain maximum growth. Only one quadrat sample in 1980 had a concentration of phosphorus less than this critical value. A concentration of 1.2 mg/g was measured in a Cladophora sample collected on July 9 from Station 10. The average concentration of total

Table 1. Average dry weights (gm/m²) and tissue phosphorus concentrations in parentheses (mg/g), 1980.

Sampling Date	Station Number								Bi-Weekly Average
	No 6	No 7	No 8	No 9	No 10	No 11	No 12	No 13	
May 28	0 (0)	66 (5.2)	7 (4.4)	0 (0)	0 (0)	0 (0)	60 (1.9)	118 (2.3)	31.4 (3.5)
June 9-10	0 (0)	398 (4.7)	183 (4.1)	122 (3.9)	0 (0)	0 (0)	248 (2.5)	358 (1.8)	164 (3.4)
24-27	0 (0)	194 (8.5)	86 (2.1)	120 (2.7)	0 (0)	0 (0)	159 (2.2)	215 (2.4)	96.8 (3.6)
July 8-9	0 (0)	103 (6.7)	131 (2.9)	154 (3.0)	198 (1.9)	95 (3.0)	185 (2.3)	110 (2.0)	122 (3.2)
21	0 (0)	135 (6.3)	0 (0)	120 (3.2)	0 (0)	0 (0)	47 (2.1)	98 (2.5)	50 (3.5)
Aug 5-6	0 (0)	67 (7.3)	84 (2.4)	14 (4.5)	0 (0)	30 (5.0)	57 (5.1)	0 (0)	31.5 (4.9)
21	0 (0)	26 (8.3)	0 (0)	30 (4.6)	0 (0)	42 (3.6)	46 (3.3)	0 (0)	18 (5.0)
Station Average	0 (0)	141 (6.7)	70.1 (3.2)	80 (3.7)	18.2 (1.9)	24 (3.0)	115 (2.8)	128 (2.4)	

Table 2. Average dry weights (gm/m²) for eight stations sampled in 1981.

Sampling Date	Station Number								Bi-Weekly Average
	No 6	No 7	No 8	No 9	No 10	No 11	No 12	No 13	
May 21	0	130	585	259	102	264	361	343	256
June 2	0	234	547	510	256	156	207	308	277
12	0	151	342	92	147	192	212	121	157
July 1	0	153	104	114	65	25	30	112	75
13	0	160	107	195	116	194	113	325	151
Aug 5	125	53	37	65	90	70	86	8	67
20	0	32	50	127	130	41	72	0	57
Station Average	18	130	253	195	129	135	154	174	

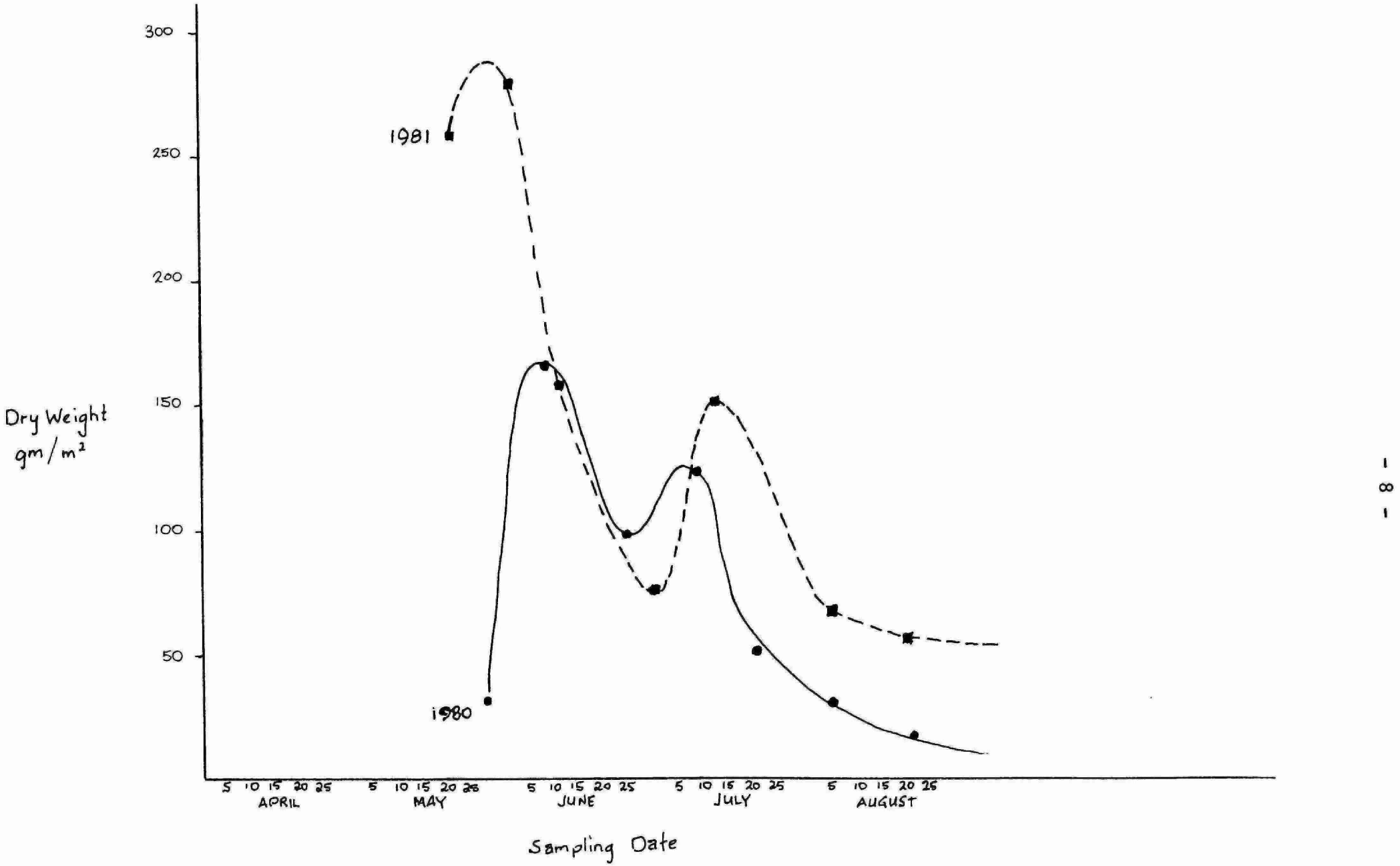

Figure 2. Average dry weight (gm/m²) based on bi-weekly samples from eight stations.

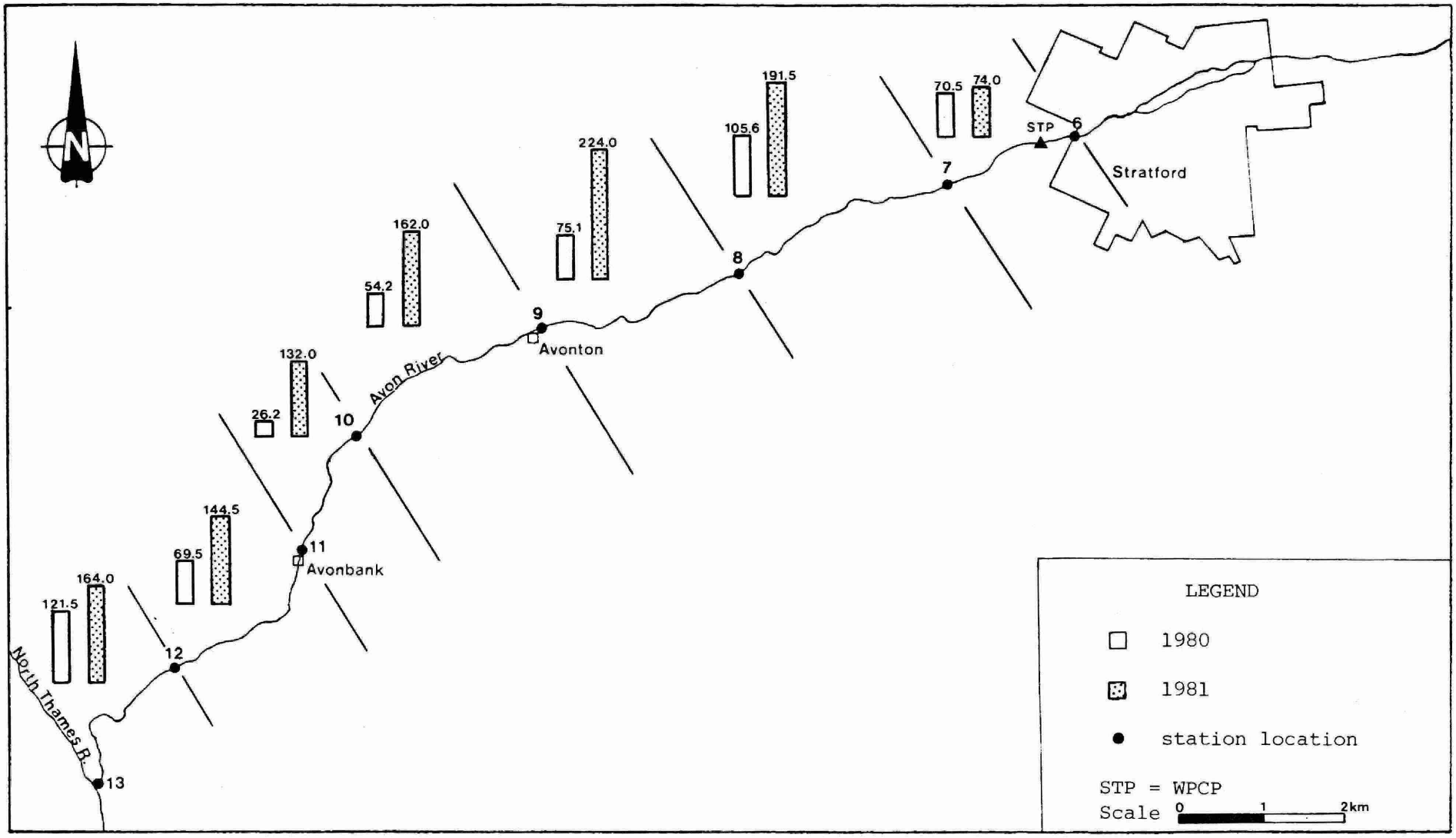

Figure 3. Seasonal (May-August) average dry weight biomass (gm/m²) for seven reaches of the Avon River, 1980 and 1981. Values are averages of the two stations at the reach extremities.

Table 3. Physical data and 1980 biomass

Reach	Station	[a]Length (m)	[a]Avg. Width (m)	[a]Avg. Depth (m)	Reach Area ($m^2 \times 10^6$)	[b]Avg. Biomass (gm/m^2)	Reach Biomass ($gm \times 10^6$)
1	6-7	1216	11.817	29.40	0.014	70.5	1.01
2	7-8	3370	14.309	29.64	0.048	105.6	5.07
3	8-9	2868	16.043	24.91	0.046	75.1	3.45
4	9-10	3074	19.912	23.64	0.061	54.2	3.31
5	10-11	2288	16.562	22.69	0.038	26.2	1.0
6	11-12	1615	20.309	18.52	0.033	69.5	2.29
7	12-13	3314	17.215	17.08	0.057	121.5	6.93

[a] From SAREMP Technical Report S-2, "Physicial Characteristics of the Avon River"

[b] Average of seven samplings (21 quadrats) per station.

Table 4. Physical data and 1981 biomass

Reach	Station	[a]Length (m)	[a]Avg. Width (m)	[a]Avg. Depth (m)	Reach Area ($m^2 \times 10^6$)	[b]Avg. Biomass (gm/m^2)	Reach Biomass ($gm \times 10^6$)
1	6-7	1216	11.817	29.40	0.014	74.0	1.04
2	7-8	3370	14.309	29.64	0.048	191.5	9.19
3	8-9	2868	16.043	24.91	0.046	224.0	10.30
4	9-10	3074	19.912	23.64	0.061	162.0	9.88
5	10-11	2288	16.562	22.69	0.038	132.0	5.02
6	11-12	1615	20.309	18.52	0.033	144.5	4.77
7	12-13	3314	17.215	17.08	0.057	164.0	9.35

[a] From SAREMP Technical Report S-2, "Physical Characteristics of the Avon River"
[b] Average of seven samplings (21 quadrats) per station.

phosphorus in plant tissues from the Avon was 3.9 mg/g with a range of 1.2 to 10 mg/g. On the average therefore plants in the Avon River contained approximately 2.5 times the concentration sufficient to allow maximum growth. Looking at the concentration of total phosphorus in plant tissue station by station (Table 1), Station 7 (closest to the WPCP discharge) had by far the highest average concentration (6.7 mg/g). The time of the year (looking at monthly averages) did not appear to affect the concentration of phosphorus in the plant tissue.

Since quadrat samples were usually a mixture of different types of plants, pure samples of Cladophora and Potamogeton (the two major plants) were also collected and analysed for total nitrogen and phosphorus. The average phosphorus concentrations for Cladophora and Potamogeton were 3.3 and 4.0 mg/g respectively. The N/P ratio for the 95 quadrat samples was 7.2/1.

A summary of weights, LOI and additional remarks for 1981 samplings is found in the Appendix.

DISCUSSION

It can be seen that the quantity of plant growth in the Avon River is both quite heavy (73.4 gm/m² in 1980 and 148.6 gm/m² in 1981) and variable from year to year. Within year variability is also evident and future studies should consider more frequent samplings. During the night-time hours (i.e. no sunlight and no photosynthesis) there was an approximate net oxygen demand by plants of 1.3 mgO_2/gm dry weight/hr (assumed value for calculation purposes). This value is likely conservative. Aiba and Ohtake (1977) in their river work found a value of 1.55 gO_2/gram biomass. Assuming 9 hours of darkness, the total demand over the 9-hour period would be 11.7 mgO_2/gm dry weight. Under conditions of very low flow, it would take the river about 72 hours to pass from Stratford to the mouth (SAREMP Report S-2). Hence, during a 9-hour night

period, the river would be subjected to 9/72 of the average stream biomass, or to 6194 kg (9/72 X 49,500). As each gram of biomass has an oxygen demand of 11.7 mg over 9 hours, the river would be subject to an oxygen demand of 72 kg over the 9-hour period.

In order to compare the oxygen demand of the aquatic plants to the demand from the sewage plant wastes, the BOD from the STP was calculated for a similar 9-hour period. Assuming 0.21 cms (4 MIGD) at 3.6 mg/l BOD_5 (using May-August 1980 records), the oxygen demand from the plant effluent would be 2 kg for 9 hours. This assumes a linear BOD_5 decay rate and that 9/120 of the 5-day BOD_5 would be exerted over any 9-hour period. It is realized that the BOD_5 curve is not linear and that many variables affect the decay rate. An exponential model, the standard tool for estimating oxygen depletion from BOD_5 decay, would give a higher estimate of decay than the linear model.*

The above calculations indicate that over a 9-hour night-time period (low flows), the ratio of oxygen demand from the aquatic plants:oxygen demand from the STP effluent is 36:1.

The net oxygen impact of the biomass is likely not as great as the ratio of 36:1 would imply, since the plants provide for supersaturated conditions at the start of the 9-hour period. However, it is evident that the river oxygen problems are very largely related to the heavy aquatic plant growth.

*See Avon River Instream Modelling SAREMP Technical Report S-9 for a more thorough modelling analysis of this problem.

REFERENCES

1. Aiba, S. and Ohtake, H., 1977, Simulation of PO_4-P balance in a shallow and polluted river; Water Research, Volume 2, 1977.

2. Ontario Ministry of the Environment 1981, Outlines of analytical methods; Laboratory Services Branch, Resources Road, Rexdale, Ontario, M9W 5L1.

3. Wong, S. L. and Clark, B., 1976, Field determination of the critical nutrient concentration for cladophora in streams; J. Fish, Res. Board Can., Volume 33, pp. 85-92.

A P P E N D I X

(Comments on aquatic plant growth
in the Avon River, May-August, 1981)

Appendix. Average wet and dry weights (gm/m²), loss-on-ignition (%) and remarks about the type and distribution of aquatic plant growth for 1981.

STATION NO. 7

Date	Average wet weight (gm)	Average dry weight (gm)	Average (%) LOI	Weighted average dry weight (gm)	Remarks
May 21	26.2	12.1	24.7	12.1	Quadrat composition 99% Batrachospermum (red algae) with some rooted aquatics (Elodea and Potamogeton spp.). 60-70% of available substrate (boulders) covered with periphyton (green in colour). Silting was noted.
June 2	51.6	21.7	25	21.5	Quadrat samples mostly Batrachospermum with some rooted aquatics. Filamentous green algae noted on rocks.
June 12	49.6	14.0	44.3	16.1	Red algae was dominant (about 80% of plant composition) Cladophora now present as other main plant component. Considerable silting noted.
July 1	92.1	14.2	59	12.8	Mostly healthy Cladophora (5-10 metre strands) with some red algae. Silting noted.
July 13	55.8	14.9	55.6	9.2	Cladophora waning; healthy where present (up to 5 metres in length). Cladophora 70-95% of quadrat composition. Red algae 5-30%. Silting noted to be heavy. Elodea and Potamogeton present.
August 5	23.7	4.9	62.6	4.2	Cladophora 10-50%; red algae 50-90%; some Potamogeton. Heavy silting noted.
August 20	13.7	3	56.3	3.8	Stressed (unhealthy) community present with Cladophora dominant. Short Cladophora strands (6") comprising 90-95% of growth. Red algae and rooted aquatics present. Rocks bare of periphyton.

Appendix (continued)

STATION NO. 8

Date	Average wet weight (gm)	Average dry weight (gm)	Average (%) LOI	Weighted average dry weight (gm)	Remarks
May 21	113.9	54.3	27.3	0	Growth mainly macrophytes (50-95%). Red algae up to 50% in one quadrat. Also some Potamogeton. Suspect Cladophora peak missed. Signs of recent high water.
June 2	164.1	50.8	27.1	55.9	30-60% Cladophora (unhealthy and heavily silted). Pretty well a mixture of Cladophora, Potamogeton and Elodea.
June 12	101.3	31.8	32	29.3	50:50 mixture of healthy Cladophora (3-4 metre strands) and Potamogeton (1 metre).
July 1	41.7	9.7	32	9.8	Cladophora 65%, Potamogeton 25%. Cladophora reasonably healthy (2-3 metre strands). Some silting. Other growth Elodea.
July 13	33.5	9.9	35.6	5.3	Cladophora (90-100%). Presence and health of Cladophora varies with flow pattern. Potamogeton present and some Elodea.
August 5	21.5	3.4	47.3	2.8	10-70% Cladophora (generally less than 12"). Potamogeton 15-40% with Elodea heavy in some areas (up to 75%). Silting evident in some areas of restricted flow.
August 20	27.2	4.6	47.6	4.6	Potamogeton 5-80% of quadrats depending on flow. Cladophora present up to 85% of a quadrat but generally not very healthy. Silting noted.

Appendix (continued)

STATION NO. 9

Date	Average wet weight (gm)	Average dry weight (gm)	Average (%) LOI	Weighted average dry weight (gm)	Remarks
May 21	56.9	24.1	25	27	Growth mostly Cladophora (90-95%) with Potamogeton (5%) and some Elodea. Cladophora generally not healthy even in good flow areas. All areas noted to be silted.
June 2	104.8	47.4	21	35.9	Potamogeton (45%) healthy 2-3 ft. strands; Cladophora still present (45%) but unhealthy looking and less than 12". Red algae very thick on rocks in riffles (10% of area) and heavily silted. Some Elodea.
June 12	38.2	8.5	36.3	8.8	Cladophora (65%) healthy, average length approximately 2 metres. Potamogeton (35%) healthy and about 2 ft. long. Heavy silting noted.
July 1	47	10.6	39	4.4	Cladophora present and appearing healthy; strand length varied from 1 ft. or less to 4 ft. Composition varied from 40-80%. Potamogeton present with lengths of 1-2 feet. Composition varied from 20-60%. Heavy silting noted.
July 13	60.5	18.1	26.5	18.3	Cladophora waning and appearing matted in 3-4 metre strands. Composition varied from 50-100% Cladophora. Quadrat composition varied from 30-50% Potamogeton (appearing healthy in 2 ft. lengths). Heavy silting noted.
August 5	27.1	6	57.6	2.9	Potamogeton dominant, comprising 15-90% of plants. Mostly 90-100% Potamogeton. Other plants a mixture of red algae and macrophytes.
August 20	93.2	11.8	74.3	12.0	Two quadrats were 100% Potamogeton which was healthy with lengths from 1-3 feet. The third quadrat was 100% Elodea. Overall the section was about 50% of each. The Elodea (4-6") was noted to be heavily silted.

Appendix (continued)

STATION NO. 10

Date	Average wet weight (gm)	Average dry weight (gm)	Average (%) LOI	Weighted average dry weight (gm)	Remarks
May 21	30.5	9.5	36.6	9.2	Growth at this station is 99% Cladophora. Distribution spotty. Healthiest in fast current (1-1½ ft.). Some Potamogeton.
June 2	57.6	23.8	30	17.8	Growth all Cladophora ranging from 2-5 ft. in length; unhealthy at some locations at the station.
June 12	38.8	13.7	31	14.8	Cladophora waning. Average length about 1 metre. Less healthy growth in some areas about 2 metres long. Silting noted.
July 1	25.3	6.0	23	2.0	100% Potamogeton in fast flow areas (25% of area). Out of fast flow, rocks are silty and covered with Cladophora stubble or periphyton (Palmella).
July 13	40.8	10.8	29.3	2.3	100% Potamogeton in fast flow areas (25% of reach). Rocks in other areas silted with little growth. One quadrat contained only periphyton (Palmella).
August 5	68.3	16.7	78	1.7	Material in quadrats all Potamogeton. This is however typical of only 20% of reach. 80% of area was bare of growth. Some isolated clumps of Elodea. Potamogeton with seed heads present.
August 20	79.2	12.1	79	1.2	Potamogeton with seed heads found in about 10% of reach. Other 90%, no growth and silty.

Appendix (continued)

STATION NO. 11

Date	Average wet weight (gm)	Average dry weight (gm)	Average (%) LOI	Weighted average dry weight (gm)	Remarks
May 21	75.8	24.5	25.6	18.5	Mostly Cladophora (99%). Health obviously linked to flow characteristics. Signs of Potamogeton (1%).
June 2	42.2	14.5	24	14.6	Cladophora healthy in main flow. Health variable as is length (3-12 ft. strands). Matting noted. Potamogeton 50% of biomass in one of quadrats.
June 12	70.9	17.8	39	15.9	Areas of good flow 100% Cladophora (6-20 ft.). Some silting in areas. Slower flow contained 50:50 Cladophora (unhealthy looking) and Potamogeton (healthy).
July 1	12.8	2.3	27	1.7	Fast flow areas cleaned of Cladophora (1" stubble) Potamogeton heavy in some areas and accounting for most of biomass.
July 14	58.1	18.0	39	10.3	Growth 95% Potamogeton. The alga, Hydrodictyon was quite prevalent in areas.
August 5	36.8	65	69	2.7	Potamogeton dominant plant. One quadrat sampled was 80% Bactrachospermum. Elodea present.
August 20	24.9	3.8	63	3.6	Growth mostly Potamogeton with Cladophora re-establishing itself in faster flow areas (up to 50% of one sample). Silting noted.

Appendix (continued)

STATION NO. 12

Date	Average wet weight (gm)	Average dry weight (gm)	Average (%) LOI	Weighted average dry weight (gm)	Remarks
May 21	151.6	33.5	46	31.2	All growth is Cladophora; 55-65% bottom cover. Some matting noted. Strands averaging 3 ft.
June 1	62.2	19.2	39	0	Strands of Cladophora grown to 12 ft. in length. Some Potamogeton starting to show. Silting noted.
June 11	61.4	19.7	43	17.6	Still mostly (90%) Cladophora. Silting noted.
July 1	25.3	2.8	33	1.0	Cladophora sloughed. Mostly periphyton (Palmella). Some Potamogeton in certain areas (35% of sample).
July 14	57.8	10.5	35	1.8	Combination of Potamogeton (80-100% at two quadrats) and Hydrodictyon 100% of third quadrat. Large areas no growth.
August 5	45.7	8.0	73	3.1	Potamogeton (growth varying from 5-95% of quadrat samples), Chaetophora (50-85% of two quadrat samples, present in third sample). Silting present near shore.
August 19	109.9	6.7	53	6.6	Mixture of Potamogeton (one quadrat only 90% of sample) and Chaetophora (found in two samples).

Appendix (continued)

STATION NO. 13

Date	Average wet weight (gm)	Average dry weight (gm)	Average (%) LOI	Weighted average dry weight (gm)	Remarks
May 21	137.5	31.9	36	38.4	All growth is Cladophora. Most luxurious in medium flow areas. Some matting observed.
June 2	79.8	28.6	32	26.9	Cladophora (5-10 ft. strands). Less growth than previous sampling.
June 12	28.6	11.2	42	11.1	Almost all Cladophora with a small patch of Potamogeton. Cladophora strands up to 24 ft.
July 1	31.2	10.4	23	7.9	Biomass consists of detached Cladophora (short stubble) and periphyton (Palmella).
July 14	65.9	30.2	34	23.1	Biomass 95% unhealthy Cladophora (stubble), some Ulothrix (4%) and Palmella (1%).
August 5	6.0	1.5	31	0.08	Very little growth. Plants present are a combination of Chaetophora (50%) and Cladophora (50%).
August 20	0	0	0	0	No growth

STRATFORD-AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT
LIST OF TECHNICAL REPORTS

S-1 Impact of Stratford City Impoundments on Water Quality in the Avon River
S-2 Physical Characteristics of the Avon River
S-3 Water Quality Monitoring of the Avon River - 1980, 1981
S-4 Experimental Efforts to Inject Pure Oxygen into the Avon River
S-5 Experimental Efforts to Aerate the Avon River with Small Instream Dams
S-6 Growth of Aquatic Plants in the Avon River
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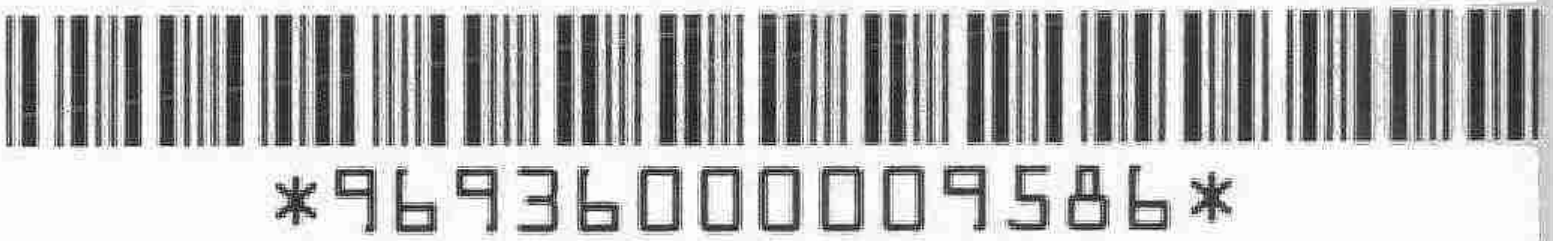
S-14 Experiments to Control Aquatic Plant Growth by Shading
S-15 Design of an Arboreal Shade Project to Control Aquatic Plant Growth

U-1 Urban Pollution Control Strategy for Stratford, Ontario - An Overview
U-2 Inflow/Infiltration Isolation Analysis
U-3 Characterization of Urban Dry Weather Loadings
U-4 Advanced Phosphorus Control at the Stratford WPCP
U-5 Municipal Experience in Inflow Control Through Removal of Household Roof Leaders
U-6 Analysis and Control of Wet Weather Sanitary Flows
U-7 Characterization and Control of Urban Runoff
U-8 Analysis of Disinfection Alternatives

R-1 Agricultural Impacts on the Avon River - An Overview
R-2 Earth Berms and Drop Inlet Structures
R-3 Demonstration of Improved Livestock and Manure Management Techniques in a Swine operation
R-4 Identification of Priority Management Areas in the Avon River
R-5 Occurrence and Control of Soil Erosion and Fluvial Sedimentation in Selected Basins of the Thames River Watershed
R-6 Open Drain Improvement
R-7 Grassed Waterway Demonstration Projects
R-8 The Controlled Access of Livestock to Open Water Courses
R-9 Physical Characteristics and Land Uses of the Avon River Drainage Basin
R-10 Stripcropping Demonstration Project
R-11 Water Quality Monitoring of Agricultural Diffuse Sources
R-12 Comparative Tillage Trials
R-13 Sediment Basin Demonstration Project
R-14 Evaluation of Tillage Demonstration Using Sediment Traps
R-15 Statistical Modelling of Instream Phosphorus
R-16 Gully Erosion Control Demonstration Project
R-17 Institutional Framework for the Control of Diffuse Agricultural Sources of Water Pollution
R-18 Cropping-Income Impacts of Management Measures to Control Soil Loss
R-19 An Intensive Water Quality Survey of Stream Cattle Access Sites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